Electron non-adiabaticity effects on parallel shear flow instability at the core/SOL transition

F. Schwander[1*], G. Ciraolo[1], A. Paredes[1], E. Serre[1], Ph. Ghendrih[2], P. Tamain[2]
[1] *M2P2 – UMR 6181 CNRS IMT La Jetée, Technopôle de Château-Gombert,38 Rue Frédéric Joliot-Curie, 13451 Marseille Cedex 20, France.*
[2] *CEA, IRFM, F-13108 Saint-Paul-Lez-Durance, France.*
** Email: frederic.schwander@centrale-marseille.fr*

The Kelvin-Helmholtz instability driven by parallel shear flow at the transition between open and closed field lines has been evoked to explain asymmetries of turbulence in Tore Supra[1]. This intrinsically three-dimensional instability results directly from velocity shear induced by sheath acceleration. The possibility of its excitation in a fluid model of an isothermal plasma with adiabatic electrons has been confirmed by local linear stability analysis of numerical equilibria of a minimal plasma edge model [2], and is confirmed in 3D global simulations of the core/SOL transition region of a limiter plasma with circular cross-section. In these numerical simulations of a minimal fluid model, the triggering of the instability requires significant core rotation (Mach number in the range 0.1-0.5), as well as a marked difference between particle and momentum transport coefficients. The minimal model used in the latter modeling however does not take into account effects of electron non-adiabaticity: particle transport is modeled by an effective diffusion in order to overcome the absence of particle transport, and the possibly destabilizing phase-shift between electric potential and particle density is neglected altogether. These limitations are lifted by allowing departure from adiabaticity in a four-field model (density-potential-parallel momentum-parallel vorticity) of the core/SOL transition, similar to that used for edge simulations [3]. This model presents severe numerical challenges, the first of which lies in the need for solving ill-conditioned linear systems in large-scale computations. The numerical method used will be presented, and illustrated by results of three-dimensional simulations of the Kelvin-Helmholtz instability in a limiter plasma with circular cross-section, with a particular emphasis on the effect of parallel resistivity in the triggering of the instability.

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